8. Reaction kinetics

8.1 Rate of reaction

Paper 1

Question Paper

1 Why does the rate of a gaseous reaction increase when the pressure is increased at a constant temperature?

A More particles have energy that exceeds the activation energy.

B The particles have more space in which to move.

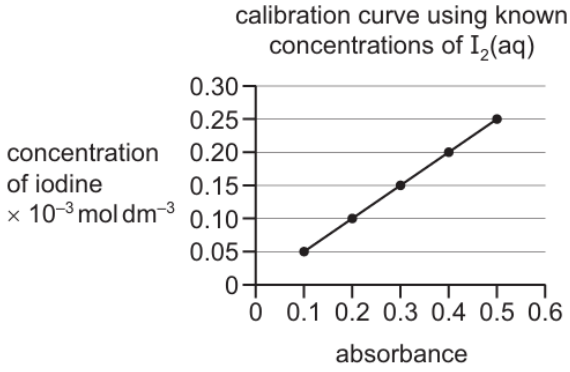
C The particles move faster.

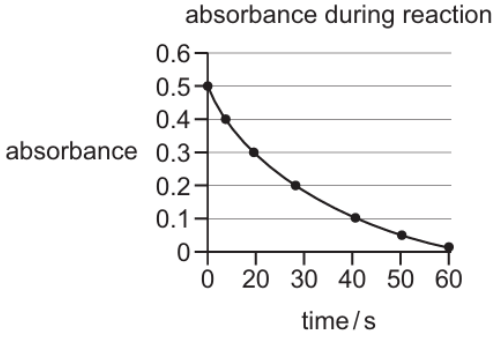
D There are more frequent collisions between particles.

2 In acidic conditions, iodine reacts with propanone in a substitution reaction.

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$$

The kinetics of the reaction are investigated using a colorimeter. As the I_2 reacts, the yellow / brown colour of the $I_2(aq)$ fades to colourless, changing the absorbance of the solution. Known concentrations of $I_2(aq)$ are used to prepare a calibration curve graph and the absorbance is then measured as the reaction proceeds.





What is the rate of reaction at 20 s?

A 5×10^{-6} mol dm^{-3} s^{-1}

B 1×10^{-5} mol dm^{-3} s^{-1}

C 5×10^{-3} mol dm^{-3} s^{-1}

D 1×10^{-2} mol dm^{-3} s^{-1}

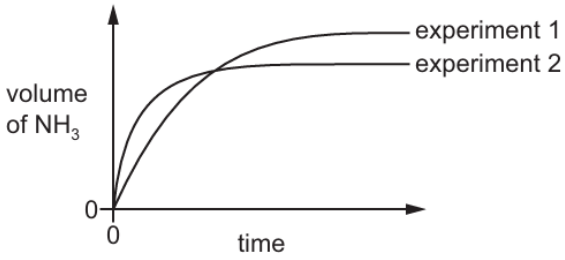
3 The volume of ammonia produced against time is measured in two experiments.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ\,mol^{-1}$$

In experiment 1, 3 mol of $H_2(g)$ and 1 mol of $N_2(g)$ react together at 45 °C and a pressure of 200 atm.

A graph showing the volume of ammonia produced against time is plotted.

Experiment 2 is then performed. Experiment 2 differs from experiment 1 in **one** condition only.



How does experiment 2 differ from experiment 1?

A An iron catalyst is present in experiment 2.

B 2 mol of helium gas is present in the reaction mixture in experiment 2.

C A pressure of 250 atm is used in experiment 2.

D A temperature of 600 °C is used in experiment 2.

4 In reaction 1, a student measures the initial rate of production of $CO_2(g)$ when $CuCO_3(s)$ is added to 50 cm^3 of 0.1 mol dm^{-3} $HNO_3(aq)$.

In reaction 2, the student repeats the experiment using 50 cm^3 of 0.5 mol dm^{-3} $HNO_3(aq)$ and the same mass of $CuCO_3(s)$.

In reaction 1 and reaction 2, the acid is in excess and samples of the same $CuCO_3$ powder are used.

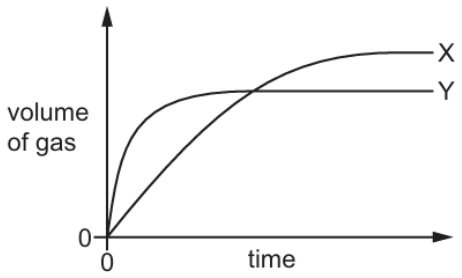
Which row is correct?

	$\frac{\text{rate of reaction 1}}{\text{rate of reaction 2}}$	$\frac{\text{initial number of effective collisions in reaction 1 per second}}{\text{initial number of effective collisions in reaction 2 per second}}$
A	greater than 1	greater than 1
B	greater than 1	less than 1
C	less than 1	greater than 1
D	less than 1	less than 1

5 The decomposition of hydrogen peroxide in the presence of MnO_2 produces water and oxygen gas.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

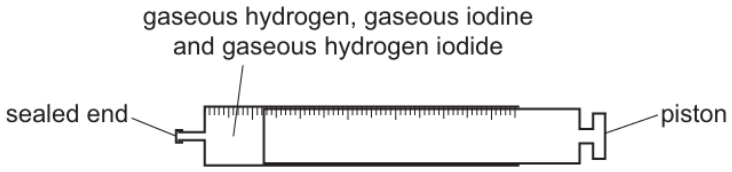
The volume of gas collected when 0.2 g of MnO_2 is added to two different hydrogen peroxide solutions at 20 °C is shown on the graph as curves X and Y.



Which row shows the conditions that will result in curves X and Y?

	curve X			curve Y		
	volume of H_2O_2 / cm^3	concentration of H_2O_2 / mol dm^{-3}	form of MnO_2	volume of H_2O_2 / cm^3	concentration of H_2O_2 / mol dm^{-3}	form of MnO_2
A	50	0.1	lumps	50	0.2	powder
B	25	0.2	powder	25	0.1	lumps
C	50	0.1	lumps	20	0.2	powder
D	20	0.2	powder	40	0.1	lumps

6 The diagram shows a gas syringe with a free-moving piston. The syringe contains gaseous hydrogen, gaseous iodine and gaseous hydrogen iodide at equilibrium.



$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

Three changes are listed.

1 increasing the total pressure by adding an inert gas and keeping the volume constant

2 increasing the pressure by adding more gaseous hydrogen iodide and keeping the volume constant

3 decreasing the volume by pushing the piston to the left

Which changes will result in an equilibrium position at which the rate of the forward reaction has increased?

A 2 only **B** 1 and 2 **C** 1 and 3 **D** 2 and 3

7 Iodine and propanone react according to the following equation.

$$I_2(aq) + CH_3COCH_3(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$$

If the concentration of propanone is increased, keeping the total reaction volume constant, the initial rate of the reaction also increases.

What could be the reason for this?

A A greater proportion of collisions are successful at the higher concentration.

B The particles are further apart at the higher concentration.

C The particles have more energy at the higher concentration.

D There are more collisions per second between particles at the higher concentration.

8 The equations for two reactions are shown.

reaction X $2NOBr \rightarrow 2NO + Br_2$

reaction Y $2NOCl \rightarrow 2NO + Cl_2$

The two reactions have similar reaction mechanisms.

The initial rate of reaction X is greater than that of reaction Y when measured under identical conditions of temperature, pressure and reactant concentration.

Which statements explain this difference?

1 The activation energy for reaction X is less than that of reaction Y.

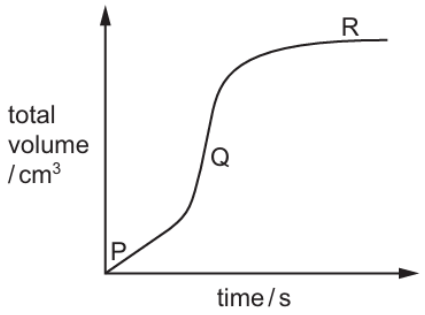
2 The Br−Br bond is weaker than the Cl−Cl bond.

3 A higher frequency of collisions between molecules of NOBr occur than between molecules of NOCl.

A 1 and 2 **B** 2 and 3 **C** 1 only **D** 3 only

9 A large excess of magnesium ribbon is added to dilute hydrochloric acid and the volume of hydrogen gas produced is measured as the reaction proceeds. The reaction is exothermic.

The results are shown.



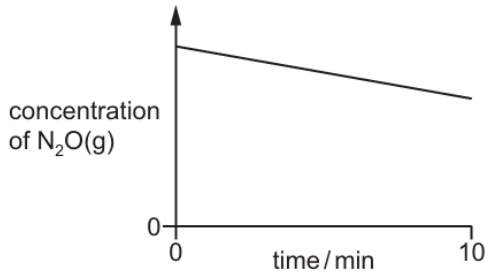
Which row explains the changes in the rate of reaction between points P and Q and between points Q and R?

	between points P and Q	between points Q and R
A	the reaction temperature is increasing	the acid concentration is falling
B	the reaction temperature is increasing	the magnesium has been used up
C	magnesium's surface area is decreasing	the acid concentration is falling
D	magnesium's surface area is decreasing	the magnesium has been used up

10 A large amount of $N_2O(g)$ decomposes into nitrogen gas and oxygen gas in the presence of a tiny amount of a gold foil catalyst.

The gold foil provides a solid surface on which the catalysed reaction takes place.

The graph shows the concentration of $N_2O(g)$ against time as it decomposes. The graph is a straight line.



Which row describes:

- the change in rate of reaction as $N_2O(g)$ decomposes from 0 to 10 minutes
- the effect of adding more gold foil catalyst on the rate of decomposition of the same amount and concentration of $N_2O(g)$?

	change in rate of reaction as $N_2O(g)$ decomposes	effect of adding more gold foil on the rate of decomposition
A	none	increases
B	none	none
C	decreases	increases
D	decreases	none

11 The Haber process for the manufacture of ammonia is represented by the equation shown.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ\,mol^{-1}$$

Which statement is correct about this reaction when the temperature is increased?

A Both forward and backward rates increase.

B The backward rate only increases.

C The forward rate only increases.

D There is no effect on the backward or forward rates.

12 Two chemicals, X and Y, react together in solution to give product Z.

The rate of formation of product Z at the start of the reaction was measured in five experiments, 1–5, using various concentrations of X and Y. The results are shown.

experiment number	starting concentration of X / mol dm^{-3}	starting concentration of Y / mol dm^{-3}	rate of formation of Z at the start / mol dm^{-3} s^{-1}
1	0.10	0.10	0.0001
2	0.10	0.20	0.0004
3	0.10	0.40	0.0016
4	0.20	0.10	0.0001
5	0.40	0.10	0.0001

Which statement is correct?

A The rate of the reaction is directly proportional to the concentration of reagent X.

B The rate of the reaction is directly proportional to the concentration of reagent Y.

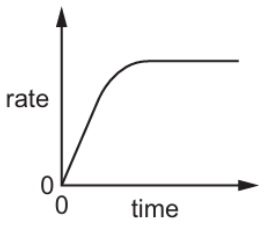
C The rate of the reaction is **not** affected by the concentration of reagent X.

D The rate of the reaction is **not** affected by the concentration of reagent Y.

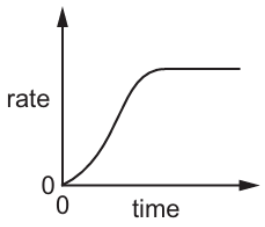
13 An autocatalytic reaction is a reaction in which one of the products catalyses the reaction.

Which curve would be obtained if the rate of an autocatalytic reaction is plotted against time?

A



B



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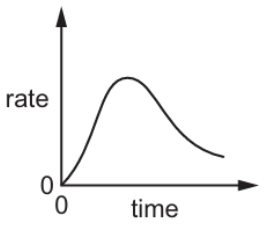
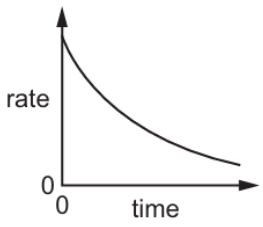


D



14 Ammonia is made by the Haber process. The reactants are nitrogen and hydrogen.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H \text{ is negative}$$

What will increase the rate of the forward reaction?

A adding argon to the mixture but keeping the total volume constant

B decreasing the temperature

C increasing the total pressure by reducing the total volume at constant temperature

D removing ammonia as it is made but keeping the total volume of the mixture the same

15 Cobalt can form the positive ion $Co(NH_3)_4Cl_2^+$.

What is the oxidation number of cobalt in this ion?

A +1 **B** +2 **C** +3 **D** +6

16 In this question you should use changes in oxidation numbers to balance a chemical equation.

Acidified potassium dichromate(VI) solution can oxidise a solution of V^{2+} ions. The equation for this reaction is shown.

$$a\,Cr_2O_7^{2-} + b\,V^{2+} + c\,H^+ \rightarrow d\,Cr^{3+} + e\,VO_3^- + f\,H_2O$$

What is the ratio $a : b$ in the correctly balanced equation?

A 1 : 1 **B** 1 : 2 **C** 2 : 1 **D** 4 : 1

17 In this question you should use changes in oxidation numbers to balance a chemical equation.

The following reaction occurs when MnO_2 is warmed with dilute H_2SO_4.

$$a\,MnO_2 + b\,H^+ \rightarrow c\,Mn^{2+} + d\,MnO_4^- + e\,H_2O$$

What is the ratio of c : d in the correctly balanced equation?

A 1 : 1 **B** 1 : 2 **C** 2 : 3 **D** 3 : 2

18 In which reaction does an element undergo the largest change in oxidation number?

A $Cl_2 + 2OH^- \rightarrow OCl^- + Cl^- + H_2O$

B $3Cl_2 + 6OH^- \rightarrow ClO_3^- + 5Cl^- + 3H_2O$

C $Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

D $3MnO_4^{2-} + 4H^+ \rightarrow MnO_2 + 2MnO_4^- + 2H_2O$